

DEPARTMENT OF COMMERCE  
Bureau of Standards  
Washington

Letter  
Circular  
LC 212

(~~Issued~~ January 17, 1928)

TESTING OF ELECTRICAL INSTRUMENTS, METERS,  
AND INSTRUMENT TRANSFORMERS

This letter circular supplements the Bureau's Fee Schedules (Nos. 132 to 1311) covering tests of electrical instruments. Its contents should be carefully noted before requesting tests of electrical instruments, meters, or instrument transformers.

All tests should be arranged for in advance of shipment of apparatus.

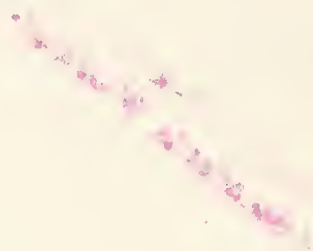
(a) Kind of instruments. - The fees given in Schedules 132 to 136 inclusive apply to regular commercial instruments of the deflection type. These instruments are understood to require no special manipulation to get a reading. When the instruments submitted for test are of the balance type (such as instruments operating on the Kelvin balance principle) and hence require more time to secure readings, or when the instruments have any unusual characteristics which increase the difficulty of making the required tests, the fees will be greater, depending on the amount of labor required.

(b) Wave form and frequency. - The alternating-current tests at usual power and lighting frequencies are regularly made with currents and voltages which closely approximate to the sine wave form.

(c) Alternating-current to direct-current transfer tests. When ammeters, voltmeters, or wattmeters of the electrodynamic type which may be operated on reversed direct current<sup>(1)</sup> and on alternating current are submitted for test on alternating current, they will first be tested on reversed direct current at the desired points, after which a determination will be made of the difference between the readings on reversed direct current and on alternating current. This "transfer test" will usually be made at two scale points. The results obtained by this procedure are more accurate and valuable than those of a test using alternating current only.

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(1) Note: The expression "reversed direct current" is used to signify the regular procedure in the use of instruments of this kind on direct current in order to avoid error caused by local magnetic field. For example, in using an electrodynamic voltmeter on direct current, two readings are taken, the direction of current flow through the instrument being reversed before taking the second reading. The mean of the two readings gives a result independent of the local magnetic field.



(d) Millivoltmeter and shunt. - The combination of a millivoltmeter and a shunt will be tested as an ammeter, and the fee will be the same as for an ammeter of the corresponding range. If the millivoltmeter is also to be tested separately, the additional fee will be as given in schedule 133.

(e) Multiple-range instruments. - It is usually best to test multiple-range deflection instruments at five scale points on one range and at two points on each other range. This procedure will be followed in cases where other instructions are not received.

(f) Instruments used with transformers. - Alternating-current instruments used with transformers should preferably be tested separately, as the transformers will in all probability have a very constant ratio over a long period of time while the instruments are more liable to change with time and use. When a transformer and an instrument are so tested, they will be counted as two pieces of apparatus, and fees will be charged accordingly. When transformer and instrument are tested separately, it is thereafter sufficient to test the instrument alone at suitable intervals, provided that the transformer is well constructed of good materials and is properly used.

(g) Wattmeters. - When single-phase wattmeters are submitted for test without specific instructions, and are of such types as may be operated on reversed direct current and on alternating current, they will be tested with reversed direct current at five points and will then be given an a.c.-d.c. transfer test (see above) at two points. This transfer test should be made at a low power factor (50 per cent) as the per cent errors resulting from inductance in the voltage circuit are much greater at low than at high power factor. A transfer test at unity power factor is necessary only in special cases. If the wattmeters have more than one range, the d.c. test will be made at five points on one range, and at two points on each of the other ranges.

(h) Polyphase instruments. - Unless otherwise specified, polyphase wattmeters will be tested first for interaction by applying alternating voltage to the voltage circuit of one element and alternating current to the current circuit of the other element and vice versa. If the interaction is sufficiently small the wattmeter will then be tested on reversed direct current with the current coils of the two elements in series and the voltage coils in parallel. A further test will be made to determine the degree of equality of the two elements at zero by opposition and at two other points on the scale by reversed d.c. tests on the separate elements. In computing the fee, the normal rating of the wattmeter so tested will be taken as the normal rating of one element.

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(i) Different voltage ranges of voltmeters and wattmeters are usually obtained by the use of internal series resistors of different values or of external multipliers. In such cases, in addition to the five-point test on one range, it is sometimes desirable to make a direct test of the instrument at two points on each other range, as thereby all conditions of normal operation, such as heating and capacitance effects are reproduced. However, in many cases where the latter source of error is unimportant, the instrument may be tested directly on one range only, and the performance on the other ranges deduced from the relative resistances of the voltage circuits as measured with full rated voltage. The reading error on the second range is thus eliminated and more accurate results are often secured. Fees for such resistance measurements to a relative accuracy of 0.05 per cent are given in schedules 133 and 136.

(j) Current transformers. - Information must be furnished as to the following test conditions. Test can not be begun until this information is received.

- (1) Test frequency
- (2) Ranges to be tested
- (3) Secondary burdens
- (4) Dielectric-strength test, if desired.

Only well-designed transformers of good construction should be submitted for test. The Bureau reserves the right to decline to make extended tests on transformers showing unduly large ratio or phase-angle errors or failure to repeat their performance. The results will in general be certified correct to 0.1 per cent in ratio and to 3 minutes in phase angle.

The wires used to connect the secondary instruments to the transformer should be included in the measurement of the resistance and reactance of the burdens. If it is not convenient to make this measurement, it will suffice for most purposes to state the maker's name, type, and serial number of each instrument, and the size and length of wire used in the secondary circuit. When the most accurate results are required it is necessary to send the secondary instruments with the transformer. The Bureau's test apparatus introduces a minimum resistance of about 0.14 ohm in the secondary circuit of the transformer under test; therefore when instruments are submitted for use as a burden, a lead resistance of not less than 0.1 ohm should be allowed.

Because of the fact that the secondary winding itself has a resistance of several tenths of an ohm, there is little to be gained by making the external burden less than 0.15 ohm. When it is essential to know the ratio and phase angle with burdens less than this, test may be made first with the minimum burden





attainable in the laboratory and second with a burden somewhat greater than this. From these two sets of data, the performance of the transformer with a burden less than the minimum can be inferred by extrapolation. Such duplicate tests will be made only on explicit order, in the absence of which, test will be made merely with the minimum burden. (See also Electrical World, Vol. 81, p.1083, May 12, 1923; Handbook for Electrical Metermen, 4th (1923) edition, p. 978).

It is customary to make the test at 0.5, 1, 2, 3, 4, and 5 amperes, and the specifying of other values within this range should be avoided.

Multiple-range transformers in which the same primary windings are used in series and in parallel usually have practically identical phase angles and proportional ratios. Hence a test on one range at six values of secondary current and on each of the other ranges at 0.5 and 5 amperes is sufficient.

Unless otherwise specified, current transformers will be demagnetized before being tested. If it is desired to have the transformer tested as submitted without demagnetization, this fact should be plainly stated.

(k) Voltage transformers. - Information must be furnished as to the following test conditions. Test can not be begun until this information is received.

- (1) Test frequency
- (2) Test voltages
- (3) Ranges to be tested
- (4) Secondary burdens
- (5) Dielectric-strength test, if desired.

Only well-designed transformers of good construction should be submitted for test. The Bureau reserves the right to decline to make extended tests on transformers showing unduly large ratio or phase-angle errors or failure to repeat their performance. The results will in general be certified correct to 0.1 per cent in ratio and to 3 minutes in phase angle.

The ratio and phase angle of a voltage transformer change linearly with changes in secondary current at constant voltage, frequency and power factor. Hence, if their values are determined for two burdens having the same power factor, values for intermediate currents may be found by interpolation. It is also possible to infer with fair accuracy the performance of a voltage transformer at any burden from data obtained at open circuit and at some one non-inductive burden at the same voltage and frequency. Formulas for this purpose are printed





on the back of the Bureau's certificate forms. When a voltage transformer is used with a secondary burden of fixed impedance, its ratio and phase angle are almost independent of the secondary voltage over its useful range. Hence a test at one secondary voltage is usually sufficient.

When the voltage circuits (potential circuits) of instruments operated from the transformer are practically non-inductive as is often the case, it is necessary only to measure the resistance of the voltage circuit of each instrument in order to calculate the burden which it puts on the transformer. If the voltage circuits are inductive, their volt-amperes and power factor at a specified voltage and frequency (or equivalent data) must be specified. If doubt exists about them, the maker's name, type and serial number of each instrument may be given, but when the most accurate results are required, it is necessary to send such secondary instruments with the transformer.

Multiple-range transformers in which the same primary windings are used in series and in parallel usually have practically identical phase angles and proportional ratios. Hence a test on one range at all the desired burdens, and on each of the other ranges at zero and at full rated non-inductive burden is sufficient.

(l) Dielectric strength of instrument transformers. - It is very desirable that the windings of both current and voltage (potential) transformers be well insulated. When requested to do so, the Bureau will make a dielectric-strength test of the insulation between the primary and secondary windings of such transformers. In the case of new apparatus the test should be in accordance with the Standards of the American Institute of Electrical Engineers. In the case of used apparatus a test at 1.5 times rated voltage plus 500 volts is suggested. Tests between the coils and core will be made only when a connection may be readily made to the core.

(m) Condition of instruments. - The Bureau can not undertake the repair or adjustment of apparatus received in poor condition. All apparatus should be in good working condition, the insulation adequate and contacts clean, etc., as apparatus which is not in good working order will not be tested. If repairs or adjustments are needed, they should be made by the applicant or the apparatus should be sent to the maker before it is submitted for test. When defects are found after a test has been begun, which exclude an apparatus from receiving the usual certificate, a report will be rendered giving such information as has been found. In such cases a special fee may be charged, depending upon the time consumed. All possible



care will be taken in handling apparatus, but the risk of injury of breakage in shipment or under test must be borne by the applicant. Instruments provided with a zero adjuster will be set to indicate zero on open circuit at the beginning of the test unless there is a definite request to test them "as received."

(n) Circular No. 20 of the Bureau of Standards entitled "Electrical Measuring Instruments" contains information on the principles of operation of electrical measuring instruments, the advantages and limitations of the various types, sources of error and their avoidance, and discusses some points of design which are of interest to the user. A brief discussion of current and voltage transformers, and an outline of the equipment required for the precision testing of electrical instruments are also given. A copy of this circular may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. for 15 cents.





